

In the Claims

1. (Original) A decoding method for retrieving information bits encoded in a printed image comprising the steps of:

receiving an input electronic image as a scanned version of the printed image;
extracting a region of interest in the image;
estimating, for said region, amount of K colorant present, denoted K_H ;
obtaining, for said region, a color value;
determining the GCR used for encoding that region using K_H and said obtained color value; and
retrieving encoded information bits based on said determined GCR.

2. (Original) A decoding method, as in claim 1, wherein estimated K_H is evaluated conditional to a capacity signal K_L and a luminance signal L .

3. (Original) A decoding method, as in claim 2, further comprising deriving from said obtained RGB data the values of K_H , K_L , and L , wherein K_H is estimated from a high resolution scan, and K_L and L are estimated from a down-scaled image, respectively.

4. (Original) A decoding method, as in claim 2, wherein the capacity signal K_L and the luminance signal L are derived from said obtained color value.

5. (Original) A decoding method, as in claim 2, further comprising determining K_L by:

applying a suitable operator S to reduce the image from scanner resolution to the watermark resolution;
converting the obtained color values to CMY estimates; and
using said estimates to determine K-colorant amount by $K_L = \min(C, M, Y)$

6. (Original) A decoding method, as in claim 2, further comprising determining K-capacity amount, K_L , by:

converting said obtained color values to CMY estimates;

applying a suitable operator S to reduce the image from scanner resolution to the watermark resolution; and

using said estimates to determine K-colorant amount by $K_L = \min(S(C), S(M), S(Y))$.

7. (Original) A decoding method, as in claim 2, wherein L is described by a linear combination of scan signals RGB, such that $L = k_1S(R) + k_2S(G) + k_3S(B)$.

8. (Original) A decoding method, as in claim 1, further comprising K_H by:

converting said obtained color values to CMY estimates;

using said CMY estimates to determine K-colorant amount at each pixel by $K = \min(C, M, Y)$; and

applying a suitable operator S to reduce the image from scanner resolution to the watermark resolution, $K_H = S \min(C, M, Y)$.

9. (Original) A decoding method, as in claim 8, wherein the operator S is a sequence of blurring filters followed by sub-sampling.

10. (Original) A decoding method, as in claim 8, further comprising converting the said obtained color values to CMY estimates by inverting scanner RGB values, such that $C=1-R$, $M=1-G$, and $Y=1-B$, such that $K_H = S \min(C, M, Y) = S[1-\max(R, G, B)]$.

11. (Original) A decoding method, as in claim 8, wherein said obtained color values are converted to CMY estimates by a 3x3 linear transformation M of scan RGB values followed by inverting, such that $CMY = 1 - (M \times RGB)$.

12. (Original) A decoding method, as in claim 8, further comprising calibrating the system by:

printing a set of patches of known CMY values;
scanning said patches;
determining RGB values of said patches;
building a transformation between RGB scan values and input CMY values; and
using said estimates to determine K_H such that $K_H = \min(C, M, Y)$.

13. (Original) A decoding method, as in claim 12, wherein the transformation is a 3x3 linear transformation M of RGB values followed by inverting, such that $CMY = 1 - (M \times RGB)$.

14. (Original) A decoding method as in claim 1, wherein K_H is estimated from a high-resolution scan by a method of thresholding the scan pixels representing the printed K dots.

15. (Currently Amended) A decoding method, as in claim 10, wherein the thresholding is performed in lightness, and dark pixels are considered part of a K dot ~~K-dot~~.

16. (Currently Amended) A decoding method, as in claim 10, wherein the thresholding is performed in chroma and lightness, and dark, non-chromatic pixels are considered part of a K dot ~~K-dot~~.

17. (Original) A decoding method, as in claim 10, wherein the threshold level for K dots ~~K-dots~~ is varied relative to the average darkness of the patch.

18. (Currently Amended) A decoding method, as in claim 2, wherein determining one out of N GCRs ~~N-GCRs~~ comprises:

determining one region of said input that was processed with each GCR; and
for each region:

computing $\beta(n, K_L, L) = E(K_H | K_L, L, \text{GCR}=n)$;

determining β that is the closest to K_H ;

creating a threshold $\tau(K_L, L) = \frac{(1/2)}{(\beta(1, K_L, L) + [\beta(2, K_L, L)]^{(1/2)})}$; and

comparing K_H to threshold $\tau(K_L, L)$.

19. (Original) A decoding method, as in claim 1, wherein K_H is evaluated conditional to the average said obtained color value of the decoding region, RGB.

20. (Original) A decoding method, as in claim 19, further comprising deriving from said RGB data the values of K_H , R, G, B, wherein K-colorant amount, K_H , is estimated from a high resolution scan, and R, G, and B are estimated from a down-scaled image, respectively.

21. (Currently Amended) A decoding method, as in claim 19, wherein estimating one out of N-GCRs comprises:

determining one region of said input that was processed with each GCR; and
for each region,

computing $\beta(n, R, G, B) \square (n, R, G, B) = E(K_H \square K_H | R, G, B, \text{GCR}=n)$;

determining β that ~~\square that~~ is the closest to ~~$K_H \square K_H$~~ ;

creating a threshold $\tau(R, G, B) \square (R, G, B) = \frac{[\beta(1, R, G, B) + [\beta(2, R, G, B)]^{(1/2)}]}{(1/2)[\square(1, R, G, B) + [\square(2, R, G, B)]}$; and

comparing ~~$K_H \square K_H$~~ to threshold $\tau(R, G, B) \square (R, G, B)$.

22. (Original) A decoding method, as in claim 1, wherein determining said GCR is accomplished by processing said estimated K-colorant amount, K_H , and said color value through a look-up table.

23. (Original) A decoding method, as in claim 22, wherein the look-up table has as inputs a transformation of scanner values.

24. (Original) A decoding method, as in claim 23, wherein the look-up table has output the estimated K-colorant amount for each of N possible GCR strategy, K_1, K_2, \dots, K_N .

25. (Currently Amended) A decoding method, as in claim 24, wherein estimating the GCR comprises:

mapping the average scanned color of the region of interest through the lookup table to obtain K estimates for each possible GCR function, K_1, K_2, \dots, K_N , ~~K_1, K_2, \dots, K_N~~ , for N GCR ~~N GCR~~ strategies;

comparing the K-colorant amount estimated from the region of interest, ~~K_H~~ K_H , to each of the said K estimates from the lookup table mapping; and

selecting the GCR function whose K estimate is closest to ~~K_H~~ K_H .

26. (Currently Amended) A decoding method, as in claim 24, in which two GCR strategies are used wherein the look-up table has as its output the threshold K-colorant value, K_T , for differentiating between the two strategies, which equal $\frac{1}{2}(K_1+K_2)^{(1/2)}$.

27. (Original) A decoding method, as in claim 25, wherein estimating the GCR comprises:

mapping the average scanned color of the region of interest through the lookup table to said obtain K_T ;

comparing said estimated K_H for the region of interest to K_T ; and

selecting said GCR function corresponding to whether $K_H > K_T$ or $K_H < K_T$.

28. (Original) A decoding method, as in claim 22, wherein an additional output of the look-up table expresses a confidence in the ability to differentiate among the different GCRs for that particular local color.

29. (Original) A decoding method, as in claim 23, wherein an additional input to the look-up table is K_H and wherein the look-up table has as its output a discrete number Q that indicates which GCR was used to print that given scanned pixel.

30. (Original) A decoding method, as in claim 29, wherein the derivation of Q comprises:

dividing the RGBK hyper-cube into N cells;

for every pixel in the image:

finding said pixel's RGBK cell; and

filling in said pixel's Q value; and

for each of said cells:

computing the histogram of the set of said Q values; and

associating said cell with the most popular Q value for that cell.

31. (Original) A decoding method, as in claim 30, wherein estimating the GCR comprises for every pixel in the low resolution image:

- computing $RGBK_H$ quadruple;
- entering said obtained RGB and said estimated K_H into the cell LUT; and
- retrieving Q thereby indicating the GCR estimation.

32. (Currently Amended) A decoding method, as in claim 22, wherein construction of the look-up table comprises:

- deriving a set of CMY data;
- processing said CMY data through each of said N GCR ~~A-GCR~~ functions to produce N sets of CMYK data;
- generating at least one target of patches corresponding to the said N sets of CMYK data sets;
- printing said at least one target;
- scanning said at least one target using the scanner to be used in the decoding of subsequent watermarked images;
- for each patch in the scanned image, estimating the amount of K-colorant, K_H , present;
- deriving a relationship between a function of said scanned signals and said amount of K_H present for each patch; and
- estimating the GCR used for encoding said image region by using the said relationship in conjunction with the said K and average scanned color for the input electronic image.

33. (Original) A decoding method, as in claim 32, wherein the target generation comprises building a separate target for each GCR function.

34. (Original) A decoding method, as in claim 32, wherein the target generation comprises building a single target that includes multi-partite patches, wherein each part of a patch is determined from a different GCR function.